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Air Force Project Competition

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Final Report

Air Force Research Laboratory
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14. ABSTRACT

JHU sent a student team to the AFRL competition in 2012, 2013 and 2014. None of the teams placed in the top 3 in any year. However every student engaged sincerely with the design problems posed by the competition and had a positive experience working with AFOSR staff and military personnel. In 2012 our student team presented a quadcopter with a specialized suction device that could fly up the side of a cliff or building and create a strong attachment point for a climb rope. The team were able to demonstrate the suction and adhesive parts of thl!ir system. In 2013 our team demonstrated an inflatable bridge that could span a 13' gap - however it was heavier than desired at 451b and the inflation system was not well resolved. In 2014 our team created a custom lift bag and an ergonomic air pump. The bag suffered a puncture while trying to lift a bulldozer. Despite these failures I am proud of all the students and their hard work, and grateful to the AFOSR for having the vision to support this competition.

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The Johns Hopkins University

Dr Nathan Scott on behalf of PI Dr Kevin Hemker

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Summary

This document records student work at each of three years of the Air Force Project Competition at The Johns Hopkins University, Baltimore, MD.

Each year one of about 15 teams of four students was assigned to the competition and used the competition as their Mechanical Engineering Senior Design project. The teams worked in an environment rich in prototyping facilities and advice. Each team presented their work to faculty every two weeks as part of a formal reporting cycle.

Team SCALE 2011-12: John Dannenhoffer, Ben Goldberg, Rob Grande & Peter Sebrechts

The challenge was to develop a system to allow soldiers to easily ascend a cliff or wall. The team developed a system to make a strong climbing attachment on a wall using a quadcopter and custom vacuum cup with adhesive.

Fig. 1 Team SCALE 2011-12 quadcopter with attached vacuum cup.

SCALE system components

The system consisted of 4 main subsystems:

1. a quadcopter to deploy the anchor point to the wall at a height of 90ft,
2. a vacuum cup to press a rope soaked in epoxy to the wall,
3. the epoxied rope for anchoring to the wall while the soldier climbs,
4. and an ATLAS powered ascender – not provided by the team - to help the soldier climb the rope with minimal effort.

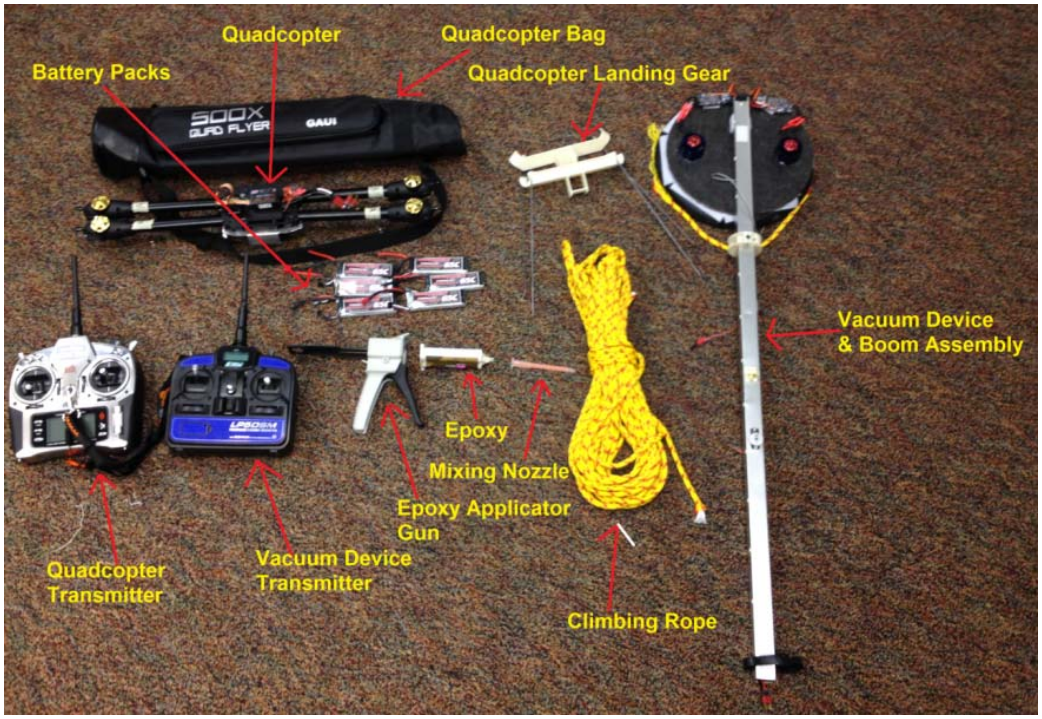

Fig. 2 All parts of SCALE system unloaded from the rucksack.

Fig. 3 Rucksack containing all the components showed in Fig. 2, total weight 13.2lbs.

The typical usage sequence is shown in the following figures.

Fig. 4 Showing epoxy application to the frayed rope attachment on the vacuum cup.

Fig. 5 The quadcopter, carrying the vacuum cup, is then flown to the attachment site and presses the vacuum cup to the wall.

Fig. 6 Left: the vacuum cup and its boom detach from the quadcopter and remain attached to the wall by suction from two ducted fans in the assembly. The epoxy adhesive cured within about 5 minutes. Right: the frayed rope bonded to a test wall.

At the competition in Dayton, OH, in April 2012, team SCALE flew their quadcopter to a height of about 50', carrying the vacuum cup and uncured epoxy. The quadcopter began to behave erratically and crashed. It was later found that one of the propellers had been insufficiently tightened.

Despite this failure the competition organizers allowed the team to demonstrate the vacuum cup and rope attachment system. A cherry picker was used to place the vacuum cup on the wall at a height of about 30'. After a 5 minute cure time a pararescue jumper used the attachment to climb the wall (Fig. 7). He had to pull hard at an angle of about 45 degrees to rip the adhesive and frayed rope off the wall, showing that at least the adhesive bond system was good.

Fig. 7 A pararescue jumper tests the frayed rope adhesive bond by putting his whole weight on it, at the competition in Ohio in April 2012.

Later, inside the test building, the team were given another chance to demonstrate the adhesive patch.

All the military personnel were uniformly polite, encouraging and helpful during the whole test process, and it was a pleasure to work with them. They genuinely wanted to bring out all the best work of the student team and give them every opportunity to succeed.

Team BRX 2012-13: Will Crawford, Ben Wasser, Renata Smith, Danny Fisher

The challenge was to create a lightweight bridge or ladder that was very small and light in the stowed or folded condition, but which could span the longest possible gap. The team created an inflatable structure by folding a commercial half-circle shaped air beam in half. It was put into a custom sock and braced with guy ropes. See Fig. 8.

Fig. 8 Ben Wasser and Will Crawford testing the bridge in April 2013.

Fig. 9 Ben Wasser carrying the folded, stowed bridge in its backpack. The pack weighed about 45lb.

The team had not resolved how to inflate the bridge in the field, which was a serious weakness of their solution. They hoped that the judges would accept that in a full military or commercial development of the system, a chemical inflator could be used.

At the competition at Eglin Air Force Base in Florida, April 2013, the team had to inflate the bridge using a mains powered air compressor. However they were then able to run the obstacle course successfully and used their bridge to span a 13’ gap and to climb a 10’ high platform.

The bridge was heavier than it should have been, since built around a commercial air beam with far more load capacity than was needed for the competition. They thought 45lb was an acceptable load for a soldier to carry – but in fact it was far too heavy.

Team AFRL 2013-14: Alexander Caffee, Aric Rousso, Vincent Wang & Dan Willen

The challenge was to lift a heavy vehicle that had fallen over in mud or on a gravel slope, using equipment that would be light enough for a pararescue jumper to carry.

Fig. 10 Team AFRL air bag, custom pump and commercial SCUBA cylinder.

Fig. 11 Aric Rousso demonstrates the custom pump.

Fig. 10 Team AFRL at Auburn Air Force Base in Tennessee, April 2014. The air bag is in the background underneath the bulldozer.

The team had some difficulty designing and implementing an inner liner for their otherwise strong multi-layer Kevlar™ bag system. They learned the hard way that the rubber inner deserves as much attention as the strength layers. Their bag was able to lift the back end of the bulldozer by about an inch, but then

suffered a blowout. They were able to demonstrate the ergonomic “stair master” action of their custom pump.

Conclusion

The competition 2011-14 was an important component of our teaching in Mechanical Engineering at JHU. 12 students during those years got to work in a unique environment with support from the Air Force. Although our teams did not place in any of those years, every team worked hard and tried very sincerely to design and demonstrate equipment for the Air Force. We hope the competition continues for many years.

1.

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Dr Kevin Hemker

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